The priming effect of point-light display (PLD) animations on the ratings of valence in neutral faces

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M.Sc. thesis
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December 2017

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M.Sc. thesis, 28 pages, 7 index and appendix pages
December 2017

Abstract

The study of human emotions is a wide topic involving different fields of study and from which countless disciplines might benefit, among them human computer interaction (HCI) and affective computing. Understanding the processes behind production, mediation and consumption of emotions via technology might increase the affective bandwidth of HCI and, as a result, improve various products and services in information and communication technologies (ICT) and in computer-mediated communication (CMC).

This thesis investigates face perception and mediation of emotional information to the users via abstract and compact graphical visualizations designed in a form of point-light display (PLD) animations. Two PLD animations consisting of a number of moving dots with different location and direction of movement were utilized in the study. One of the animations represented a face smiling while the other represented a face frowning. Earlier studies have demonstrated a potential of such PLD design in affecting emotional ratings of the users. Further investigation is needed to examine whether PLD animations have an effect and can influence the response to another stimulus.

Therefore, in this work priming paradigm is used as a research method to study the implicit memory effect that PLD animations might have on the valence ratings of neutral faces (photographs). 29 participants were asked to rate the valence of neutral faces shortly presented (100 ms) after PLD aminations using a 0-6 rating scale. Moreover, participants were asked whether they perceived faces and facial expressions from the PLD animations.

Results showed that participants perceived faces and facial expressions (smile and frown) from the PLD animations. On the other hand, paired sample *t*-test found no significant effect from the PLD animations on the valence ratings of neutral faces. The results obtained might be explained by the limitations of the experimental tasks, the rating scale implemented and the length of the PLD animations. The thesis discusses the results and suggests possible improvements to the weaknesses observed in the current design.

Keywords

Point-light displays; Facial expressions; Biological motion; Priming; Affective computing; Emotions

Contents

1. Introduction

The study of facial expression and emotional information perception is an important topic for human-computer interaction (HCI) and a key factor for affective computing. Understanding how humans perceive computer-generated facial expressions and emotional information might lead to both: a better comprehension of human emotions perception system, especially while interacting with technology; and gaining useful knowledge which might be applicable for conveying emotions to the user and detecting emotions from the user. Moreover, it might lead to improve various products and services in information and communication technologies (ICT) and in computer-mediated communication (CMC).

This thesis delves into human perception of basic and simplistic computer-generated facial expressions by utilizing point-light display (PLD) stimuli in order to analyse their impact on facial expression and emotional information processing. Next, the background literature will be reviewed and the objectives of the thesis will be formulated.

1.1. Point light displays (PLDs)

PLDs have been used during decades in order to study biological movement, facial expressions and emotion recognition. PLDs consist of small motionless or dynamic circular light sources (Johansson, 1973). In studies using PLDs, those lights are located in places responsible for movement such as joints, in order to study for example, the perception of human motion. Even though each one of the light sources is perceived individually, humans are able to perceive a complete motion pattern out of them (Johansson, 1973). Thereby, human body in motion might be represented through several dots in movement. In a study by Johansson (1973), reflecting material was attached to the limbs of human actors wearing black clothes, while the actors were walking over a black background. The study discovered that humans recognize the group of dots in motion and define them as a human walker. Moreover, the study demonstrated that humans distinguish human biological motion from other patterns of movement such as random motion signals or the movement of other animals such as mammals.

The utilization of PLDs to study the recognition of information from human face and facial expressions has a solid background. PLDs allow simple representations of complex sources of information and have been used for decades as research stimuli. For example, PLD animations have been used to study child and adult sensitivity to gender information in patterns of facial motion (Berry, 1991). Moreover. Recently, PLDs have been introduced in neuroscience to study which parts of the brain were responsible for facial expression information processing (Ichikawa et al., 2010; Atkinson et al., 2012). In the next section, the literature about PLDs and facial movement will be described.

1.2. PLDs and facial movement perception

Bassili, (1978; 1979) suggested that PLDs could be used to investigate the elementary processes of human perception. Bassili hypothesized that the movement, which is inherent of any facial expression, plays a crucial role in human face perception and also in the perception of the emotional information transmitted through the face. In his studies, Bassili used actors whose faces were covered with black makeup and numerous white spots, omitting the main facial features (eyes, eyebrows, nose and mouth). Then, the actors were recorded performing facial expressions so only the motion of the PLDs was perceptible. In one of the studies, participants observed both, the video recorded of the PLD facial expressions and real facial expressions. During the study, facial expression recognition was measured. Bassili found that, the errors in the facial expression recognition were similar in the two experimental conditions (PLD facial expressions and real facial expressions). Those results highlighted the importance that motion has in human facial expressions recognition. Furthermore, using the same conditions Bassili studied the role that different parts of the face have in the recognition of facial expressions. Bassili discovered that the lower part of the face was necessary for recognizing happiness, sadness and disgust, while the upper part was required for recognizing anger and surprise.

PLDs were utilized by Afzal et al. (2009) in order to study how different feature points convey affective information in facial expression recognition. In their study, three different representations of four facial emotional expressions were generated: PLD animations, 3D Xface avatar animations and stick figure animations. They found that PLD animations had higher recognition rate than the 3D Xface animation. Similarly, Pollick et al. (2003) used PLDs in order to investigate the perception of emotional expressions (sadness, happiness, surprise and anger) in two studies. PLDs were composed by 30 dots representing the shape of the face, mouth, nose, eyes and eyebrows. In the first study, the motion of facial expressions was modified by spatial exaggeration and in the second study the time properties of the movements were modified (the motion was speed up or slowed down). In both studies emotion recognition and intensity ratings of that emotion were measured. The results of the first study showed that manipulating the exaggeration of the facial expressions had a significant effect on the ratings of intensity of that emotion. However, timing manipulation had a small effect on ratings of emotional intensity. These results confirmed the hypothesis proposed by Bassili (1979) suggesting that the movement in facial expressions has an important effect on the perception of the human face and emotion-related information.

Masuzaki and Sato (2008) conducted three studies in order to investigate facial expression recognition through PLDs. They aimed to evaluate the role of motion information in the perception of facial expressions. In the first study they aimed to derive the minimal number of dots required for recognizing the expressions of sadness, anger, happiness and surprise. They modified the number of dots representing those facial expressions. PLD representations composed by 10, 14, 18 and 34 dots where used for each expression. They found that the recognition of the facial expression was better when the number of dots increased from 10 to 18 for happiness, anger and surprise. Moreover, the results for the facial expression of sadness showed a steady improvement in the recognition rates throughout all four conditions (10, 14, 18 and 34 dots). In the second study, Masuzaki and Sato studied the recognition of the same facial expressions with 18 dots or less. However, this time they introduced two new experimental conditions: for the first condition, an expressive representation of the PLDs was shown twice (repetitive condition); for the second condition first a neutral representation was shown followed by the expressive representation (apparent motion condition). In both cases, there was 80 ms blank time between both frames. The results showed that facial expression recognition improved in both conditions when the number of dots increased. Surprise and happy faces returned higher performance. As expected by Masuzaki and Sato, the motion (apparent motion condition) improved the perception of angry, happy and surprised faces when the amounts of dots was small. However, motion had no effect for the sad faces. In order to confirm the role of the motion on the results obtained in the second experiment, Masuzaki and Sato, run a third experiment. They utilized the same design used in the second study but this time they introduced a white field between frames in order to reduce the effect of the motion. The results showed that the improvement found in the second experiment disappeared (except for the surprise facial stimuli). Masuzaki and Sato concluded that motion information was responsible for the improvement in the performance discovered in the second experiment. Those results, confirmed later by Cunningham and Wallrave (2009), seem to point out that the recognition of a facial expression is possible with minimal spatial data when motion of that facial expression is introduced.

Previous research has primarily used the discrete emotions theory while studying PLDs. A discrete emotions theory defends that emotions (such as happiness or sadness) are different constructs, that is, emotions represent specific patterns which are represented in the body and the brain differently (Ekman, 1992; Izard & Ackerman, 2000). According to the discrete approach, each emotion is defined by specific facial expressions and other biological processes, frequently referred to as basic emotions.

However, Venesvirta et al. (2016) further highlighted the importance of studying simplistic and controlled representations of human facial movements and their emotional effects using a dimensional emotions theory (e.g., Schlosberg, 1954), which suggests that emotions can be characterized using a set of dimensions. Dimensional models of emotion propose that an interconnected and common neurophysiological system might be responsible for all affective states, in contrast with the theories of discrete emotions, which propose that different emotions arise from separate neural systems (Posner et al., 2005).

The PLD animations proposed by Venesvirta et al. (2016) were represented as two parallel rows of six dots each over a black background. The animations represented the movement of the upper and the lower rows of dots (the eyebrows and lips, correspondently) in the locations that were found critical by Bassili (1979) for the recognition of anger (in the upper face) and happiness (in the lower face). The intensity of the expression was defined by the angle (low/10º, middle/20º and maximum/30º intensity) of the movement from its starting to ending position.

Venesvirta et al. (2016) divided participants in two groups. Half of the participants were informed about the presence of face while the other half was not informed. Participants were instructed to rate the animations according to their valence (intrinsic attractiveness / averseness of an event, object, or situation), arousal (intrinsic activation / calmness of an event, object, or situation), dominance (being in control / not being in control of an event, object, or situation), and approachability (avoidability / approachability of an event, object, or situation). The results showed that half of the participants of the non-informed group recognized a face from the PLD animations. Moreover, when the movement was located in the lower row of dots, participants rated the animations as more pleasant, relaxing and approachable than the corresponding upper row located movements for the intensities of 20º and 30º.

Based on the literature analysis, it can be concluded that PLDs convey facial expression related cues, including face presence, gender and emotional information. More research on the topic is required to better understand this phenomenon. Furthermore, it should be investigated whether the emotional information conveyed by the PLD animations might be transferred to other stimuli. The traditionally used method for this type of investigation is priming that will be described in the following section.

1.3. Priming

Priming is a type of implicit memory that has been defined as "unintentional retrieval of previously acquired information on tests that do not require conscious or explicit recollection of specific previous experiences" (Schacter et al., 1991). According to the priming paradigm, a previously presented stimulus (prime) has an effect on a second stimulus presented later (target). The priming paradigm provides control over the effect that a certain prime stimulus has on cognitive and emotional processing since the same target stimulus can be introduced following different prime stimuli. Hence, different results for different prime stimuli indicate that the prime has an effect on the processing of the target stimulus.

There are several priming types, such as repetition priming (Burton et al., 2005), affective priming (Murphy & Zajonc, 1993), perceptual priming (Wiggs & Martin, 1998) or semantic priming (Bruce & Valentine, 1986). In semantic priming, the prime and the target share the same semantic category and possess similar features (Neely, 1977). For example, the word smile is a semantic prime for happy, because both are related to emotion. Among other stimuli, semantic priming effect has been found in faces (Bruce & Valentine, 1986). According to Reisberg (1997), semantic priming is theorized to work because of spreading activation: the prime stimulus activates a particular representation or association in memory before performing an action or a task. Then, when the second stimulus, the target, is encountered, the representation is already partially activated and less additional activation is required to become consciously aware of it.

Priming paradigms have been used to determine whether affect influences associations. The assumption was that mood serves as a node in memory that is linked to other valence-congruent nodes. If the assumption was correct, positive moods should activate positive concepts whereas negative concepts should be activated by negative moods (Storbeck & Clore, 2008).Those associations were assumed to occur automatically, with no intention (Neely, 1991; Bargh, 1992). Affective priming using facial expressions has shown that facial expressions can behave as direct elicitors of affect. People are able to detect emotional facial expressions unconsciously while this information influences the evaluation of the target stimuli (Carroll & Young, 2005). Hence, affective priming is a reliable measure of affective associations (Klauer & Musch, 2003).

Affect has been studied within priming paradigms using different sorts of stimuli, including pictures (Srinivas, 1993), words (Fazio et al., 1986) or facial expressions (Murphy & Zajonc, 1993). Moreover, affect has been investigated in priming studies using different sorts of tasks, such as lexical decisions (Neely et al., 1989), pronunciations (Keefe & Neely, 1990) or evaluative categorization (Fazio et al., 1986). Therefore, priming paradigm have proved to work as a versatile tool for studying affect related issues.

Valence ratings seem to be influenced by the similarity between prime and target stimuli: responses to a target are facilitated when it is preceded by a prime congruent in valence. For example, the reaction time for evaluating a target stimulus as positive or negative is shorter when prime and target share the same valence (positive-positive; negative-negative) than when the valence is different (positive-negative; negative-positive) (Fazio et al., 1986). Similar effects have been found using positive and negative faces as target stimuli (Burton et al., 2005). However, according to my knowledge there appears no studies addressing the effect of positive and negative primes on the ratings of valence neutral faces as target stimuli.

Facial stimuli have been largely investigated in memory research and priming. Several studies have reported that memory for faces is enhanced when participants are asked to provide affective judgements about faces compared to other neutral evaluations such as the size of facial feature (Biber et al., 1981; Bower & Karlin, 1974). Further, it has been found that memory for faces was better for pictures with emotional content compared to pictures with neutral content. For example, Burton et al. (2005) used repetition priming paradigm to study the priming effects in neutral and affective faces. They found that face recognition accuracy was better for affective faces in comparison to neutral faces. It seems that the memory for neutral faces is significantly worse than that for affective faces.

Even though faces have been largely studied in priming studies, there are few works in which face categorization have been used as dependent variable and faces as target stimuli. For example, Johnson, Kim and Rise (1985) used faces as target stimuli in an implicit memory study within the priming paradigm framework. In their study, first participants heard a short story (few paragraphs) which was either positive or negative. Then the participants were shown pictures of people and were asked to categorize them according to their preference. The results showed that the ratings of preference of the faces varied in function of whether a story presented with each of the faces was negative or positive. The results were impressive considering the fact that participants (diagnosed with Korsakoff's) had impaired explicit memory for stories and faces. It seems then that faces used as a target stimuli might be influenced by the nature of positive or negative primes.

1.4. Aims and objectives of the thesis

The current thesis intends to continue with the research started by Venesvirta et al. (2016) by utilizing the PLD designs proposed for maximum intensity of the upper and lower expressions (the PLD designs will be described in more detail in the methods). The thesis further expands the scope of investigation by studying whether the proposed PLD animations have an implicit memory effect and can influence the response to another stimulus, in particular, a photograph of a neutral face. In order to support a direct comparison with the earlier work, the current study will also adopt the dimensional categorization of emotions, in particular, the dimension of valence and analyse deeply how it is affected by the PLD animations.

The first objective of this work is to further investigate whether the PLD animations convey information about face presence and facial expressions. While Venesvirta et al. (2016) tested a sample of Finnish students; the current study involves a sample of Spanish students. Nevertheless, it is anticipated that the participants from both cohorts share the ability to recognize face smiling and frowning from the proposed PLD animations. Therefore, it is expected that participants will be able to perceive a face and facial expressions (smiling and frowning) from the PLDs animation.

The second objective is to investigate the effects of the movement location and movement direction of the PLD animations on the ratings of valence of neutral target stimulus. Within the priming paradigm, PLD animations will be utilized as primes for neutral faces, which will be the target stimuli. Thereby, we will be able to determine whether the processing of neutral faces has been affected by the earlier presentation of PLD animations. It is expected that movement location and direction of PLDs have an effect on the valence ratings of neutral faces. Therefore, participants are expected to rate faces more positively (negatively) after the movement is located in the lower (upper) row of the PLD animation.

2. Methods

2.1. Pilot study

A pilot study was run before the experiment in order to correct possible problems and adjusts the setting.

Five participants took part in the pilot, which was run in the same premises as the current study and with the same apparatus. In the pilot study, the tasks were designed using the same stimuli and the procedure was the same described below for the current experiment. However, a dichotomous method was used for the valence ratings: participants had to rate valence as positive or negative by pressing two different keys in the keyboard ("L" and "D" respectively).

Participants suggested that they were not comfortable with the rating method originally designed. All participants pointed out that it was difficult to categorize the target stimuli as positive or negative. Participants reported that the valence of the majority of the pictures was neutral or close to neutral. As a result, participants suggested that it would be better to implement a scale-based rating method offering more options instead of a dichotomous rating method.

2.2. Participants

Twenty-nine voluntary Spanish-speaking participants (12 males, 17 female) took part on this study. The mean of the participants' age was 28, ranging from 23 to 34. All participants reported to possess normal vision (or corrected to normal with spectacles/contact lenses) and a level English of B2 or higher, according to European framework (Council of Europe, 2011).

2.3. Apparatus

A regular laptop PC (Lenovo ThinkPad Ultrabook X250 with 2.80 GHz Intel CORE i5 processor and 8 GB RAM) with 64 bit Windows 10 Professional was used for the experiment. The experimental task was implemented using Microsoft PowerPoint 2010. The external display utilized was a 19″ Dell P1917S, with a screen resolution of 1920×1200. Participants were seated in front of the screen with 90 cm of viewing distance. Participants used the numerical keys (0 to 6) from an external keyboard (Microsoft Wired Keyboard 600) in order to enter the valence ratings. The experiment was performed in a sound-attenuated usability laboratory.

2.4. Stimuli

Prime: PLD animations

The stimuli used as a prime in this study was developed and utilized by Venesvirta et al. (2016). The PLD animations were designed as two horizontal and parallel rows. Each row was composed by 6 dots that fluctuated in a small-pixel neighbourhood; all of them had the same size and an equal distance between them. The dots were displayed into an imaginary square (6×8 cm) and fitted over a black background. This disposition of the dots was defined as a neutral representation of the PLDs (Figure 1, left picture). Two different animations were created based on the PLDs' neutral disposition. In both cases, the neutral disposition was the start and the end of the animations. The two animations differed on the direction and location of the movement. In the *upper movement* animation, the motion was located on the upper row of dots and consisted of a downwards movement of the four inner dots (Figure 1, right picture). In the *lower movement* animation, the motion was located on the lower row of dots and consisted of an upward movement of the four outer dots (Figure 1, middle picture). In both cases, the movement ended when the migrated dots created a 30º angle from the starting position and then the inverse movement started until the dots reached the neutral disposition.

The PLD animations created by Venersvirta et al. (2016) were divided in five equal phases: 1) First all dots fluctuated in place; 2) Either the *upper movement* or the downward movement started while the other dots fluctuated in place; 3) At the apex of the movement all dots fluctuated in place; 4) The dots which moved from the neutral disposition returned to their initial position while the dots fluctuated in place; 5) When the dots returned to the neutral position, all dots fluctuated in place. The total length of an animation was 12.29 s.

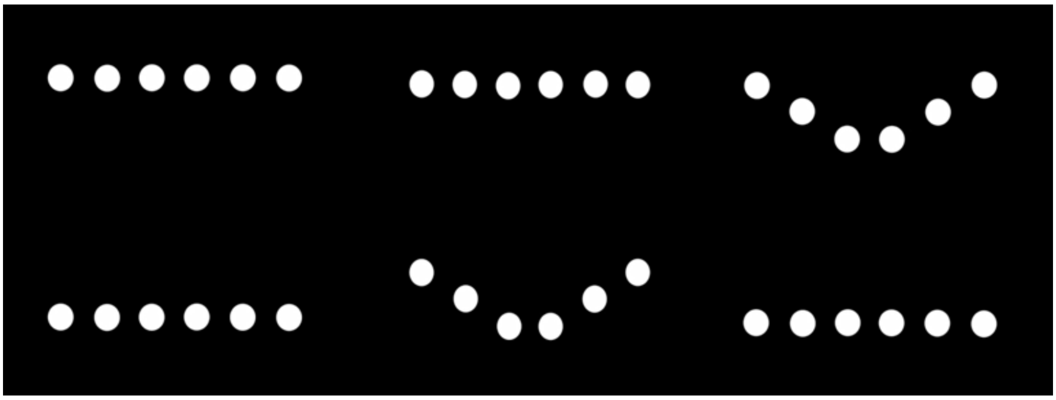

Figure 1. PLD stimuli. The left picture represents the neutral position (start and end of the movement). The other two pictures represent the apex of the movement in the *lower movement* condition (middle picture) and the *upper movement* condition (right picture).

Target: Neutral faces

The target stimuli were extracted from the Cohn-Kanade AU data set (Kanade et al., 2000; Lucey et al., 2010). In total 6 emotionally neutral faces were selected. The faces selected belonged to three ethnically white men and three ethnically white women (Figure 2). The size of the target stimulus was 4×3.5cm.

Figure 2 Examples of the targets used during the tasks (©Jeffrey Cohn).

Rating scale

The rating scale was developed according to the findings in the pilot study. Therefore, a 7-point bipolar scale was implemented as rating method for the experiment. The scale ranged from 0 to 6, 0 being the most unpleasant value and 6 being the most pleasant value and 3 the neutral value.

Research in valence has been approached using different bipolar scales of different ranges. For example, 9-point bipolar scales ranging from 1 to 9 (Gerdes et al., 2010); 9-

point bipolar scales ranging from -4 to +4 (Venesvirta et al., 2016); or 6-point bipolar scales ranging from 1 to 6 (Sweeny et al., 2009). For the current study, due to the apparatus limitations a simple entry method using the keyboard was needed. Therefore, a scale including only positive values was implemented. The 7-point scale was implemented in order to shorten the available options, similar to Sweeny et al. (2009). However, compared to Sweeny et al. a neutral value was included in order to offer the possibility of neutral answers.

Tasks

The tasks in the experiment were composed by five items presented in a time sequence (Figure 3).

First, a fixation cross was presented in the middle of the screen for 1000 ms in order to get the participant`s attention. Then, the prime stimulus (PLD animation) was presented for 12.29 s. After the prime, a fixation cross was presented again in the middle of the screen for 1000 ms in order to get the participant’s attention. Then, the target stimulus was presented for 100 ms After the target stimulus, a slide appeared on the screen asking the participant to make a decision about the valence of the target stimulus. The participant had to make the decision within 4 second time window, after which a new task was presented to the participant. If the decision was made faster, the participants could to move to the next task by pressing a space bar of the keyboard. The decision consisted on rating the target stimulus according to its valence using the 7-point bipolar scale described before. Between the end of each task and the beginning of the next task there was a pause of one second, and during the pause the screen was black. All text instructions on the slides were provided in English.

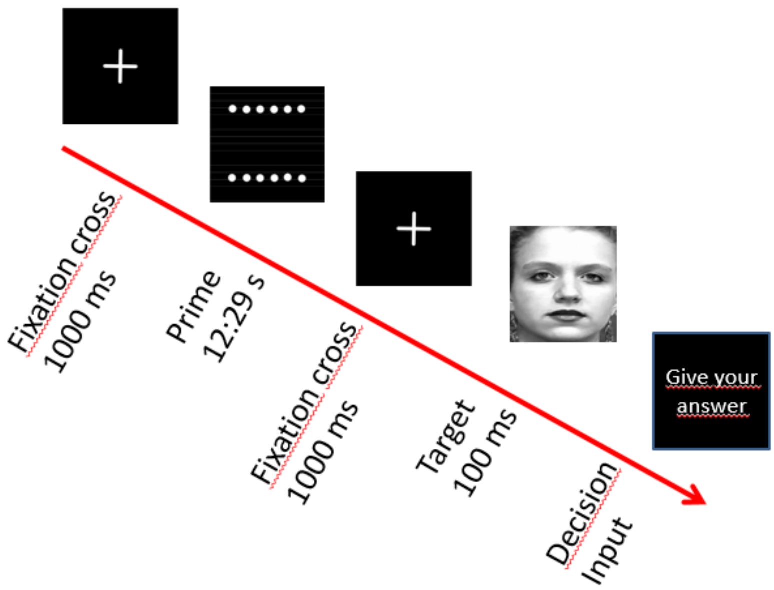

Figure 3. Experimental task time flow (Target picture by ©Jeffrey Cohn).

2.5. Procedure

Prior to the experiment, the participants were informed about their rights as experimental participants. Before starting the experiment, every participant filled in a consent form accepting the participation in the experiment (Appendix 2) and a background questionnaire (Appendix 1). All participants were given the same set of instructions about the experiment. All instructions, questionnaires and forms were provided in English.

First, the participant completed a practice trial. Before starting the practice, the valence rating scale was explained to the participants with written instructions. The participants were asked to always provide an answer and to guess the valence of target stimulus if they were unsure about the response. In order to provide the rating for each task, participants were asked to use the keyboard with the keys 0 to 6, 0 being the most unpleasant value, 6 the most pleasant value, and 3 a neutral point. The practice trial consisted of four decision tasks with the same structure and time flow as the experimental tasks (Figure 3). The only difference was the lack of movement in the PLD animations. A static neutral disposition of the PLDs was shown for 12.29 s.

After the practice trials, the participant proceeded with the experimental trial. In total, there were 36 decision tasks. The *upper movement* prime preceded a neutral face target stimulus in 18 tasks and the *lower movement* prime preceded a neutral face target stimulus in 18 tasks. For each one of the 36 presentations, the participants rated the target stimuli according to its valence using the same rating scale introduced in the practice trial. Participants had a one-minute resting time after 12 tasks if they choose.

When all the task were completed, participants were asked to fill in a short end questionnaire (Appendix 3). First, questions 1 and 2 were given to all participants. Then, questions 3, 4 and 5 were given to the participants who reported seeing a face in question 2. Finally, questions 6 and 7 were given to all participants.

At the end of the study, the experimenter briefly debriefed to the participants the aim of the study and asked the participants no to inform their peers about the study. Moreover, the experimenter asked permission for using and publishing the data.

2.6. Data analysis

The experiment was a single factor repeated measures within-subjects design. The only independent variable was the PLD animation, which had two levels, namely, the *upper* and *lower movement* design, and the experiment was counterbalanced regarding it. The total number of responses collected was: 29 participants × 2 PLD animations × 18 = 1044. Four responses were removed from the analysis due to the fact that participants pressed a key other than 0-6, which left a total of 1040 rating measurements.

The data collected during the experiment was analysed using the IBM SPSS Statistics 23 software package. A paired-samples *t*-test was conducted to compare the valence ratings provided by the participants for both levels of the independent variable.

3. Results

A paired-samples *t*-test was conducted to compare the valence ratings provided by the participants for the *upper movement* and the *lower movement* conditions (Figure 4). There was no significant difference between the ratings of valence for the *lower movement* location and the *upper movement* location conditions, $t\ (28) = 2.04$, p = n.s.

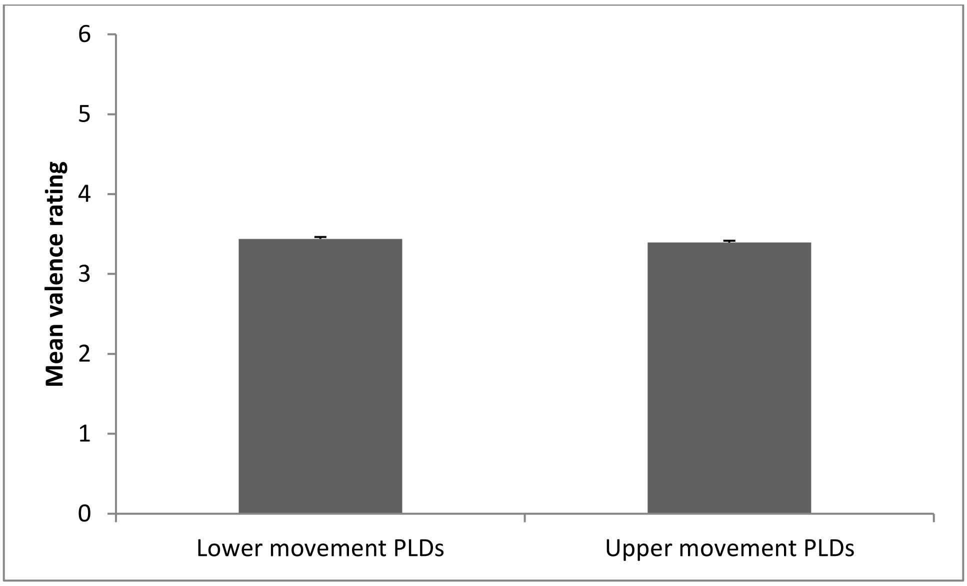

Figure 4. Means and Standard Error of the Mean (SEM) for both experimental conditions.

The results of the end questionnaire showed that most of the participants (n=28) saw a face in the PLD animations as well as a specific facial expression: a face smiling (n=28) and a face frowning (n=25). Participants reported that they saw a happy face (n=22), an angry face (n=20) and a sad face (n=5) from the PLD animations. All participants reported they saw the pictures, but none of them describe them as neutral faces. (Table 1).

Question	Answer	Percentage
1	Saw the pictures	100%
3	Saw a face in the animations	96.5%
4 and 5	Saw a face smiling	96.5%
	Saw a happy face	75.9%
	Saw a face frowning	86.2%
	Saw an angry face	69%
	Saw a sad face	17,24%

Table 1. Responses obtained from the end questionnaire.

All participants reported that they did not follow any special reasoning to rate the valence of the faces and that they rated the target stimuli according to what they perceived (Question 7). Finally, all participants reported that they were able to keep themselves attentive and concentrated during the whole study.

4. Discusion

The current study had two main research objectives. The first objective was to verify whether the PLD animations convey information about face presence and facial expressions, while the second objective was to investigate priming effects of the PLD animations on the rating of valence of neutral target stimuli.

Regarding the first objective, the results obtained from the end questionnaire showed that the PLD animations convey information related to facial expression and the associated emotional information (Table 1). Thus, the majority of the participants (n=28) were able to recognize faces from the PLD animations, according to the initial hypothesis. The percentage of participants who recognized a face from the animations was higher in this study than in the study conducted by Venesvirta et al. (2016). In their study, only half of the participants (50%) from the non-informed group reported to have seen a face. A possible explanation for a higher percentage of those who perceived a face in the current study might be that the target stimuli (neutral faces) were associated with the PLD animations, representing a smiling and a frowning facial expression. Explicit presence of face photographs as target stimuli in the current study might have activated a link between the PLD animations and the real faces.

Moreover, the fact that for this study only the maximum intensity PLD animation (30º) was utilized might be an explanation. The 30º animation exaggerates more the representation of the facial expression, helping the recognition of the face and its parts. This explanation is in line with the study Pollick et al. (2003) which concluded that exaggeration had a significant effect on intensity and emotion recognition of facial PLDs. Unfortunately, the percentage of participants who perceived a face from the different intensities of PLD animations in the study by Venesvirta et al. (2016) was not measured. Therefore, it is impossible to compare these results with the results obtained by Venesvirta et al.

The participants reported not only perceiving the face and its parts from the PLD animations, but also seeing an expression of frowning and smiling ($n \geq 25$ participants). Many participants ($n \geq 22$) attributed a particular emotional meaning to the animations, seeing PLDs as the representations of happy and angry faces. These finding seem to be in line with the results obtained by Matsuzaki and Sato (2008). In their study, participants were able to recognize happy and angry expressions from very simple PLD representations generated from real facial expressions. Therefore, the results of this thesis might suggest that expressions of happiness and angriness might be perceived similarly from computer-generated PLDs and real facial expressions. Moreover, is interesting to notice that the participants recognized similarly the smiling expressions and the frowning expressions. These results are not in line with earlier findings (Bassili, 1979; Venesvirta et al., 2016) in which smiling expression (*lower movement* condition) was recognized in a higher degree than the frowning expressions (*upper movement* condition) from the PLD animations. That difference might be explained, as suggested before, by the explicit presence of face photographs which might have activated a link between the PLD animations and the real faces. Therefore, the presence of a real face might have helped the equal perception of both expressions (smiling and frowning) from the PLD animations.

Regarding the second objective, the results showed that the abstract computer-based PLD animations had no significant effect on the ratings of valence of neutral faces. Thus, in contrast to the initial hypothesis, the ratings of valence for the target faces were not affected by the emotional information carried out by the animations. It seems that perceiving the animation frowning or smiling had no effect on the quick perception of neutral faces (Figure 4).

This is an interesting result because nearly all participants recognized the two different PLD animations and were able to categorize them as smile and frown (Table 1). The fact that the emotional information was not transmitted to the neutral faces might be explained in terms of long time exposure to the faces (100 ms) and the long interval between the onset of the prime and the onset of the target (stimulus-onset asynchrony or SOA). It might be that the long SOA along with the long target exposure prevented the association of both prime and target stimuli.

Moreover, results might suggest that priming is not a suitable paradigm to investigate the matters addressed by this work due to the length of the PLDs animation. The length of the animation (12.29 s) increases the SOA significantly. Previous research proved that priming effect is stronger when the SOA is shorter than 1000 ms (Hermans et al., 2001).

On the other hand, the nature of the rating scale used in the study might be an explanation for the results. The presence of a neutral value in the rating scale seems to have guided participants' answers. Results show that the mean of participants' responses in both conditions (*upper* and *lower movement*) is close to the neutral value of the scale (3) which indicates that participants judged the valence of the faces as neutral. It seems that offering a clear neutral answer in the scale avoided that participants made a positive or negative choice about the valence of the target faces. Moreover, the instructions given to the participants, in which the presence of the neutral value was highlighted, made even more obvious the existence of a neutral choice. Future research should force participants to choose and do not provide an explicit neutral option in the rating scale.

The participants rated the valence of the neutral faces as slightly positive. Thus, in both experimental conditions, the mean of the rating was higher than 3, which is supposed to be the neutral rating as it was situated in the middle of the measurement scale (Figure 4). A possible explanation for that might be the nature of the chosen face photographs. The participants might have perceived the neutral faces as slightly positive. Faces convey a wide variety of information about an individual (Rossion, 2014) and the mere structure of a person's face affects others' impressions of that person (Zebrowitz & Montepare, 2008). The rating might also be affected by the mood of the participants, as emotional states could bias the recognition of emotionally neutral faces (Leppänen et al., 2004).

To conclude, the results of this work confirm the earlier findings about human perception of faces and the associated emotional information from PLDs. Humans are able to perceive facial expressions from PLDs representations, which implies that for mediating such information not only photographic representations of faces but also abstract and simplistic computer-generated graphical visualizations can be successfully used. This opens up a vast potential for PLDs as bearers of emotional information in technology-mediated communication.

Thereby, the results from this study might be used in affective computing and HCI. As suggested by Venesvirta et al. (2016), PLDs might be utilized for example in order to enhance artificial intelligence systems which are designed to recognize facial expressions from videos or pictures. Moreover, PLDs require a very small amount of information to be transmitted, there is no need for high-definition displays. Therefore, artificial PLDs might be used to convey socio-emotional information in CMC.

However, this study failed to prove any effect from the PLD animations on the neutral faces. Therefore, at this point it is necessary to point out the limitations of the current study design and suggest improvements.

The results of this study are limited by the tool utilized to create the tasks (Microsoft Power Point) which is not a software designed for experimental purposes. Therefore, the tasks developed for this study were subjected to the limitations that impeded a stimulus presentation quicker than 100 ms. Reducing the presentation time of the target face would have an effect on the categorization of that target face. Even tough recent research suggest that faces might be perceived as quickly as about 13 ms (Hagmann & Potter, 2016) the processing time of a face takes between 100 and 200 ms (Rossion, & Jacques, 2011). Future research, might study whether PLD animations have a priming effect on the neutral faces when the time of presentation of those neutral faces is closer to the suboptimal threshold. In order to do that, a sophisticated experimental design software, allowing faster and accurate stimuli presentation, should be used to create the tasks.

Moreover, as explained before, the rating scale used in the study might have influenced the results biasing the participants towards neutral responses. Thereby, future research should include in the experiment design a rating scale with no neutral value, so participants would be forced to provide a positive or negative response when rating the valence of the target stimulus (neutral faces).

The length of the PLD animation is also a limiting factor for the study. As explained above, the length of the animation increased the SOA affecting the association between the prime and the target. Therefore, shorter PLD animations (1000 ms) might be implemented in future research, using the same design to address the objectives of this study.

Finally, an alternative study design is suggested to further study whether PLD animations have an effect and can influence the response to another stimulus. Hence, a study to investigate the facilitatory effect that PLDs might have on positive and negative target faces is recommended. Studying the facilitatory effect that the PLD animations might have on the perception of positive and negative faces (measuring response time along with accuracy) might bring information about the relationship between the PLDs and emotion recognition. Once more, a behavioral experiment software providing milliseconds precision timing needs to be used in order to perform the suggested study.

5. Conclusion

This study was aimed to continue with the work started by Venesvirta et al. (2016), which investigated emotional reactions towards basic, artificial and controllable point-light display animations. Venersvirta et al. concluded that PLD animations convey emotional information. The current study had two objectives. First, the study aimed to further investigate whether the PLD animations convey information about face presence and facial expressions. Second, the study aimed to investigate the effects of the movement location and movement direction of the PLD animations on the ratings of valence of neutral target stimuli. Priming paradigm was introduced to address the second objective.

On the one hand, the results obtained in this research failed to prove any significant effect from the PLD animations on the valence ratings. Therefore, this work could not conclude that the emotional information is transferred to other stimuli. On the other hand, this study confirmed that the participants perceived faces and facial expressions from the animations. The later results complement Venesvirta et al. (2016) work and provide further evidence that PLD animations are capable of conveying face related information.

One of the main limitations of the current design were the experimental tasks. Being developed using regular office software, the tasks possessed weaknesses limiting the outcomes of the study. Therefore, future research using a software designed for experimental purposes in order to create the tasks, might bring results supporting the initial hypothesis regarding the second objective of the study. Moreover, a new rating scale without a neutral value would be required in order to force participants to provide positive or negative responses and prevent neutral ratings.

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7. Appendices

Appendix 1 Background Questionnaire

Age ___ in full years

Gender

[ ] female [ ] male

Do you have normal vision?

[ ] Yes [ ] No [ ] Corrected to normal with spectacles/contact lenses

Are your English skills B2 or superior (according to the European language framework)?

[ ] Yes [ ] No

Appendix 2 Consent Form

CONSENT FORM: The effects of simple animations to the decision of valence of sub-optimally presented pictures

GENERAL: You are invited to participate in an experiment to examine the effect of point-light displays on human emotion recognition (represented in this case by valence).

DESCRIPTION: During the experiment you will be presented several sequences of stimuli. In each one of those sequences you will be asked to make a decision at the end. The decision will consist on judging if the stimulus presented later has positive or negative according to its valence. A keyboard will be used to complete the task.

Before the experiment, you will have to perform a practice task to better understand your duty.

RISKS AND BENEFITS: The experiment does not involve any risk to the participants. If for some reason you are unable to continue at some point, you may withdraw from the test at any time. Coffee/tea and cookies will be provided for participants after the experiment.

DURATION: Conducting the experiment will take approximately 30 minutes.

PARTICIPANT RIGHTS: All the data collected during this experiment will be handled anonymously will be reported and analyzed on a group level, and cannot be directly linked to an individual participant. Participation is voluntary, including the right to cancel your approval at any time without consequences.

CONTACT INFORMATION: If you have any questions, concerns or complaints about this experiment, please contact Marc Belles (645 724 908, marc.belles@ludus-vr.com).

By signing this consent form I agree to participate in the experiment, and understand that there is no monetary compensation for participating. I also understood that my participation is voluntary and I am entitled to refuse to participate or withdraw from participation at any time without consequences.

SIGNATURE ____

PRINTED NAME ____

DATE AND PLACE ____

Appendix 3. End Questionnaire

1. Did you see what was in the *pictures*? If you did please describe:

2. Did the animations you saw remind you about any objects or things you have seen in real world?

3. Did you see a face in the animations?

4. If you think you saw a face in the animations, which parts of the face were present?

5. If you think you saw a face in the animations, what happened on the different parts of the face?

6. This experiment was quite long and requires effort from the participants. Could you tell from your own perspective whether you were able to keep yourself attentive and concentrated during the whole study?

7. Could you tell which what the reasoning for answering either positive or negative was?

Appendix 4. Procedure

The priming effect of point-light display (PLD) animations on the ratings of valence in neutral faces pictures

INSTRUCTIONS:
[TURNING MOBILE PHONES OFF]

1. **Welcome**

Hi, thanks for coming.

In this experiment, you will need to attend to a sequence of stimuli composed by an animation and a quick presented picture, and make a decision about them.

To begin with, I would like you to fill this form regarding your participation in the experiment

[READING THE LETTER OF INFORMATION AND SIGNING CONSENT FORM]

We are also collecting background information, I would like you to fill this short questionnaire.

[COLLECTING BACKGROUND INFORMATION]

2. **General description of the experiment**

In this experiment, we examine the effect of point-light displays on perception of stimuli.

In this study, we will address the concept of valence.

Do you know what emotional valence is?

If not explain to the participant:

> ***Valence****, within psychology framework, especially in discussing emotions, means the intrinsic attractiveness (positive valence) or averseness (negative valence) of an event, object, or situation. Therefore, if a stimulus is pleasant means its valence is positive and if it is unpleasant means its valence is negative.*

Do you have any question at this point?

If there are not question continue:

3. **Experiment tasks**

As you have no questions, I will proceed to explain you the experiment and the experimental task you will have to perform.

Note that, the instructions of the experiment will be shown to you again prior to start with the test.

During the experiment, you will see an animation followed by a quick presentation of a picture. Your duty will consist on deciding if the later picture was pleasant or unpleasant.

You are asked to rate the picture using a 0-6 rating scale, 0 being the most unpleasant and 6 the most pleasant. Use the keyboard on the desk in order to provide the answer. Before and after of each trial you should keep your hand behind the white line in front of the keyboard.

You are supposed to provide an answer in each task, guess the answer if you are not sure.

A practice pretest set of tasks will be run so you can train the decision task.

During the experimental tasks, I will be in the room next door controlling the correct functioning of the experimental tool.

Do you have any question at this point?

If you have no questions, we will proceed with the practice tasks.

Are you ready?

[Experimenter places the participant in the correct position in front of the screen and about 90 cm from the monitor and explains it to the participant.]

4. Instructions for the experiment

Before we start the test, I would like to remind you that participation is voluntary, and you have the right to withdraw your participation at any time. If doing so, you do not need to give any reason, but feedback is always welcome. Remember also that we are not testing you; there are not right or wrong answers.

5. Experimental trial

At this point, we will proceed to the experimental tasks. Please pay attention to the monitor and pay attention to the instructions that appear on the display.

As I have explained you before, it is very important that you provide an answer to all stimuli.

Do you have any questions?

Well, if you have no further questions I will leave the room so you can start. I will be in the room next door controlling that the experimental tool runs properly.

[EXPERIMENTER RUNS THE EXPERIMENTAL TOOL AND LEAVES THE ROOM]

6. The trials are finished

[EXPERIMENTER COMES INTO THE ROOM]

Now I will ask you few questions about the tasks you have just performed. After that, the experiment will conclude.

[END QUESTIONNAIRE]

Thank you for your participation.

It is very important not to tell any detail of this experiment to your peers in the next month.

7. **Debriefing.**

At this point the experimenter tells the participant the aim of the experiment and asks permission for using the data and publish it.

[OFFER SOME REFRESHMENT TO THE